PROJECT : # Encircle

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Contents

Acknowledgements

Information presented in this document has been prepared by:

Locus Research
Timothy Allan, Blythe Rees-Jones, Kylie Baker

Agresearch
Stewart Collie, Alex Tasker, Carolyn Piper, Ian Fowler

Levana Textiles
Verne Atmore, John Baker, Marie Snell

Medical Research Institute of New Zealand
Dr Richard Beasley

Christchurch Hospital
Dr Justin Roake

Introduction

The Encircle project was established in 2007 by Levana Textiles to explore new opportunities to create non-invasive compression technologies for the aged care sector utilising the company's knitting expertise. The initial intention of the project is to create a new healthcare business venture within Levana for the manufacture and supply of Merino compression garments that can assist in the prevention of a wide range of common elderly skin and venous conditions.

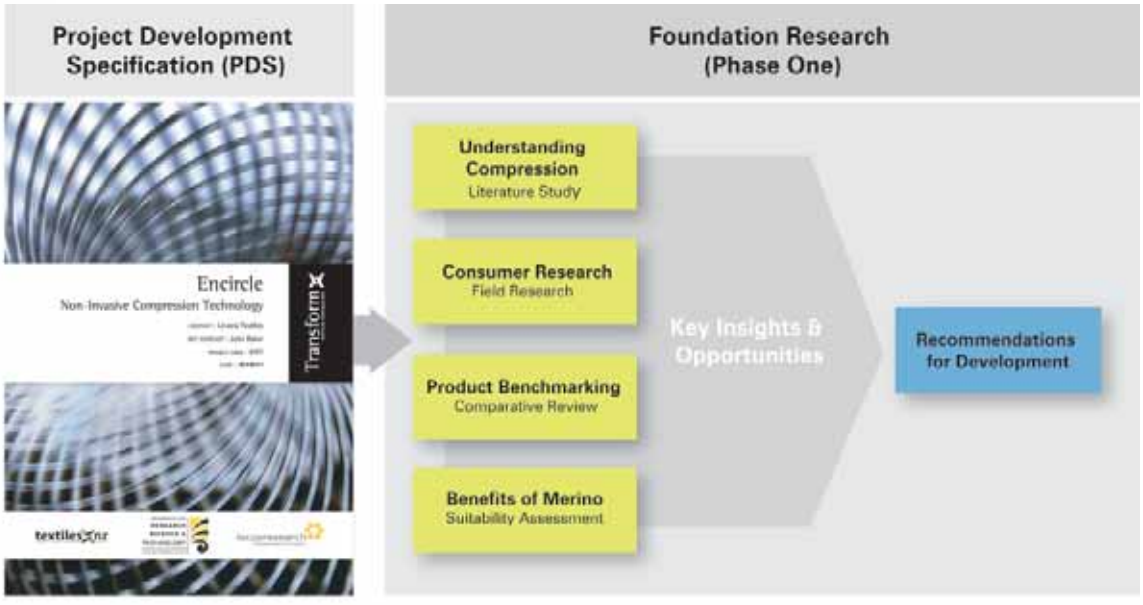
The first stage of the project included the creation of the Project Development Specification (PDS) within the Textiles New Zealand Transform Initiative. This initial study established the basic parameters and sufficient technical information for the project.

This booklet forms a succinct summary of the foundation research which encompassed the following four specific and more in-depth studies conducted in the PDS phase:

- **Understanding Compression** – a detailed investigation exploring the mechanisms behind compression and the physiological effects that external compression therapy can have on the prevention of common skin issues and venous insufficiencies
- **Consumer Research** – field research concluded to develop a broader picture of the requirements of the older adult and all those involved in the specification of compression products, from diagnosis through to application and use.
- **Product Benchmarking** – detailed comparative product assessment of the existing state of the art compression products which established the existing benchmark for compression therapy. It also provided a method to identify how other manufacturers are approaching the topic.
- **Benefits of Merino** – technical assessment of Merino's suitability in next-to-skin therapeutic applications.

The key insights and opportunities from the investigation are presented in this booklet. A number of recommendations for the development of a new systematic preventative compression system have also been made to drive the next phase of the project.

Figure 1. This diagram provides an overview of the key stages in the project to date and illustrates the four components of the Foundation Research.

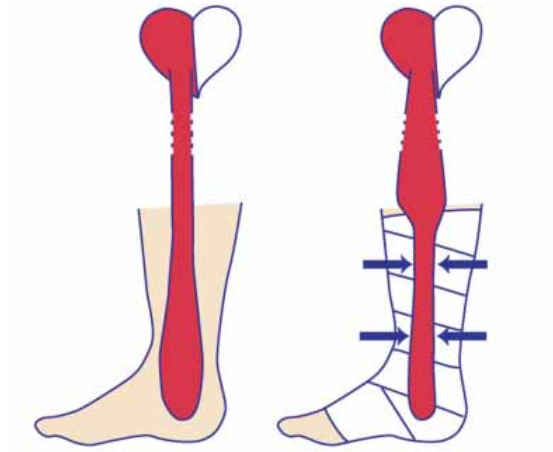


Understanding Compression

External compression works by applying controlled pressure to the skin and venous system to reduce the diameter of the veins in the extremities. This results in a reduction of venous hypertension (elevated blood pressure or HTN) and hydrostatic pressure (backward flow of blood in the veins also known as venous reflux) which is an essential mechanism for preventing common skin issues and venous insufficiencies such as oedema, venous eczema, ulceration, and thrombosis in the older adult.

Figure 2. Compression Overview

Compression of the leg veins leads to a shift in blood volume with an increase in the preload of the heart.



The Venous System

Veins function to return deoxygenated blood to the heart, and are essentially tubes that collapse when their lumens are not filled with blood. The thick, outer-most layer of a vein is comprised of collagen, wrapped in bands of smooth muscle while the interior is lined with endothelial cells. Most veins have one-way flaps called venous valves that prevent blood from back flowing and pooling in the lower extremities due to the effects of gravity. The precise location of veins is much more variable from person to person than that of arteries .

To ensure adequate venous return from the lower limbs, the superficial veins, deep veins, bicuspid valves and muscles must all work together. The deep veins in the body carry blood back up the leg and consist of two posterior tibial veins, two anterior tibial veins and two peroneal veins which join up to form the popliteal vein which in turn continues into the femoral veins. These veins are situated deep in the muscles of the leg and are protected by a fibrous fascia.

The large volume of blood carried by these veins results in a high pressure within the vein walls, whereas the superficial veins, consisting of the long saphenous veins, short saphenous veins and numerous superficial collaterals, satellites and confluents of the saphenous veins, carry a smaller volume of blood at a lower pressure.

The superficial veins drain into the deep veins by means of the perforating veins. Bicuspid valves, present in both superficial veins and deep veins, ensure that the flow of blood is unidirectional and when these valves are competent they prevent a backflow of blood from the deep veins to the superficial veins.

In a standing individual, blood flows slowly through the veins. The venous pressure, which equals the weight of the blood column between the foot and right atrium, is about 80-100 mmHg. During walking, however, blood flow is accelerated by the combined action of the calf muscle pump and the foot pump which forces the blood upward out of a segment of vein. Relaxation of the calf muscle allows the now empty segment of deep vein to refill with blood from the superficial veins and thus the cycle is repeated. In patients with competent valves this accelerated flow decreases

Figure 3. Venous System

Cross section of a vein showing a valve which prevents backflow. Venous valves prevent reverse blood flow.

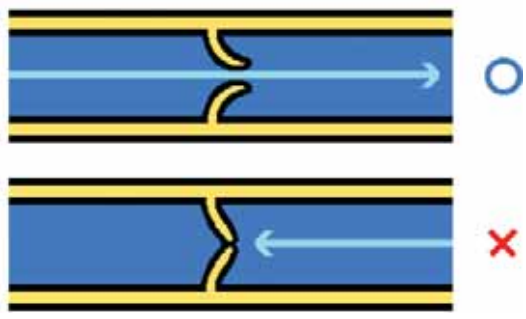
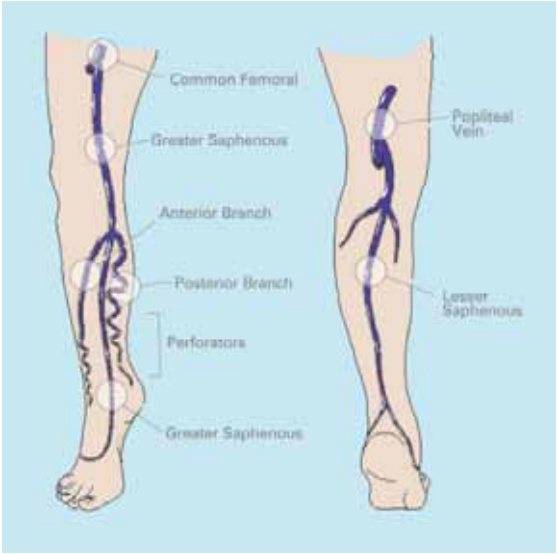


Figure 4. Long and short Saphenous System

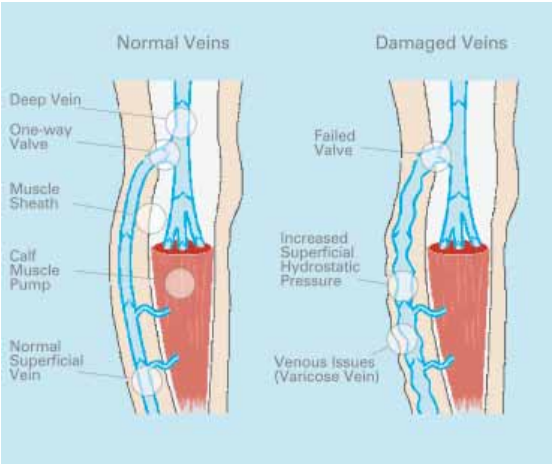


the volume of venous blood in the foot and reduces venous pressure to about 10-20 mmHg.

If the valves in the large veins become incompetent, blood will oscillate up and down in those segments lacking functional valves. The resulting backward flow of blood in the veins of the lower leg (also known as venous reflux) leads to a reduced fall in venous pressure during walking (known as ambulatory venous hypertension). This is most significant when the backflow occurs between the deep and superficial veins, as the increased pressure in the superficial veins will cause further valve incompetence. This is because the valve cusps no longer meet as a result of the reflux and stretching of the veins.

The overall effect of this is increased superficial hydrostatic pressure which may cause the aching and throbbing and chronic venous insufficiency,

Figure 5. Venous System (normal and damaged)



which in turn causes fluid loss into the tissues and the formation of oedema, varicose veins, lipodermatosclerotic changes, varicose eczema and leg ulceration.

Compression Mechanics

The application of adequate levels of compression reduces the diameter of major veins. This has the effect of reducing local blood volume, by redistributing blood towards central parts of the body.

Reducing the diameter of major blood vessels also has a secondary effect of increasing flow velocity, provided the arterial flow remains unchanged. The clinical significance of these effects depends upon the relationship between the intravenous hydrostatic pressure and the degree of external compression applied.

The degree of compression produced by an external system can be determined by:

1. physical structure and elastomeric properties of the compression system
2. size and shape of the limb to which it is applied
3. skill and technique of the application
4. nature of any physical activity undertaken by the patient

The pressure generated by the compression system is determined principally by the tension in the fabric, the number of layers applied, and the degree of curvature of the limb. The relationship between these factors is essentially governed by Laplace's Law.

Figure 6. Laplace's Law

P # T/R

- P = represents pressure
- T = tension
- R = radius
- # = proportional

Applied pressure is directly proportional to the tension in the compression but inversely proportional to the radius of curvature of the limb to which it is applied (P increases with T but P decreases as R increases)

The compressive tension is determined initially by the amount of force applied to the fabric during application. The ability of a product to sustain a particular degree of tension is determined by its elastomeric properties, and these in turn are a function of the composition of the yarns and the method of construction.

Short-stretch items should be capable of up to 70% extension with long-stretch items capable of

over 140% extension. With elastic compression a small change in extension (as might occur during walking) will result in minor fluctuations in sub-garment pressure. These items are also able to accommodate changes in limb circumference, which occurs when oedema is reduced, with minimal effects on sub-garment pressure.

Types of External Compression

Several types of elastic and inelastic compression products are currently used within the aged care sector and the broader healthcare market. Within these two areas there are a wide range of different configurations of compression products. The common products used are single and multi-layer bandages, and graduated compression hosiery.

Single & Multi-Layer Bandages

Single & multi-layer bandages can incorporate both elastic and inelastic materials which provide the advantages of both systems: the elastic element provides sustained pressure, and the inelastic element provides high pressures during walking and low resting pressures.

Bandages are classified within the British Standard (BS 7507) into one of six categories. Type 1 refers to retention, lightweight, elastic bandages. Type 2 support bandages (inelastic, short stretch) and type 3A to 3D are compression bandages (elastic, long-stretch). The four classes of compression bandage are defined according to their ability to apply a specified sub-bandage pressure to a known ankle circumference (23 cm) where the bandage is applied with a 50% overlap between successive layers.

Figure 7. Proguide Multi-layer Compression

Table 1. British Standard (Elastic Bandage)

Group RAL-GZ	Type BS7505	Level of Compression	British Standard (mmHg)
1	3A	Light	Up to 20
2	3B	Light	21-30
3	3C	Moderate	31-40
4	3D	High	41-60

Graduated Compression Hosiery

Graduated compression hosiery exerts an external pressure which is greater at the ankle and reduces at the calf and thigh, thus increasing blood velocity within the deep venous system.

In compression hosiery the daily build-up of pressure is controlled by the limited ability of the hosiery to stretch so incompetent venous valves are approximated, venous return is accelerated, the fibrinolytic activity of the venous wall is increased, and the risk of thrombosis and other issues reduced.

Table 2. Classification of Compression Hosiery

Class	Approximate Pressures	Support	Indications for use
Class A	10-15 mmHg	Light	General prevention, light oedema, tired aching legs
Class 1	15-21 mmHg	Mild	Slight varicosity, mild oedema; Heaviness and tired aching legs; Prophylaxis of venous disorders; prevention of varicosities during pregnancy.
Class 11	23-32 mmHg	Moderate	Chronic venous insufficiency; varices with a tendency to oedema; After recovery from ulceration of the leg; After vein surgery and sclerotherapy; More severe varicosities during pregnancy; prevention of lymphedema of arm post-breast surgery/radiotherapy
Class 111	34-46 mmHg	High	Severe varices with marked oedema; Severe chronic venous insufficiency; Severe post-thrombotic syndrome; Lymphedema
Class 1V	49+ mmHg	Strong	

Figure 8. Types of External Compression

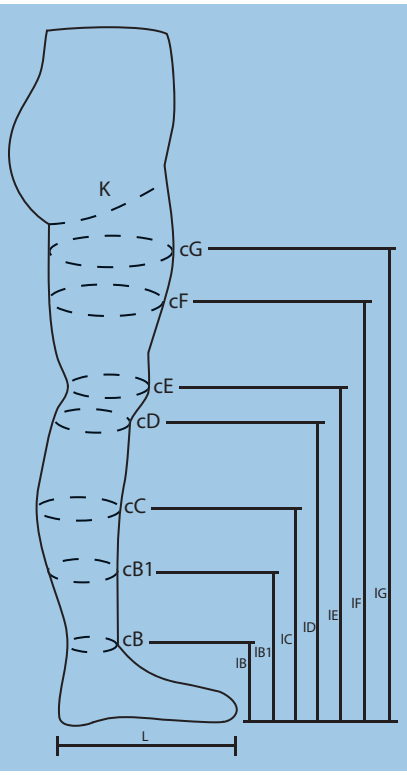
Hosiery is classified within the British Standard (DD ENV 12718) into five classes ranging from light pressure (Class A) through to strong compression (Class IV). Like bandages, these classes of compression are defined according to their ability to apply a specified sub pressure to a known ankle circumference.

According to this standard profile a garment with a compression value at the ankle of 15 mmHg should have a compression value at the calf less than 80% of this (i.e. 12 mmHg) and a value at the thigh less than 85% of the calf measurement

Table 3. Non-Prescriptive Graduated Compression

B (Ankle)	D (Calf)	G (Upper Thigh)
Compression Value mmHg	Proportion of ankle compression at calf	Proportion of calf compression at thigh
6>10	<100%	<100%
11>18	<80%	<85%
19+	<70%	<70%

Figure 9. Measuring points, lengths, and girths on the human leg



B	ankle at the point of its minimum girth
B1	point at which the achilles tendon changes into the calf muscle
C	calf at its maximum girth
D	just below the tibial tuberosity
E	centre of the patella and over the back of the knee
F	between K and E
G	5cm below K with the patient in upright position
K	girth of upper thigh just below gluteals

(i.e. 10.2 mmHg). The percentage decreases as the ankle compression value increases to ensure maximum flow of the blood back up the venous system.

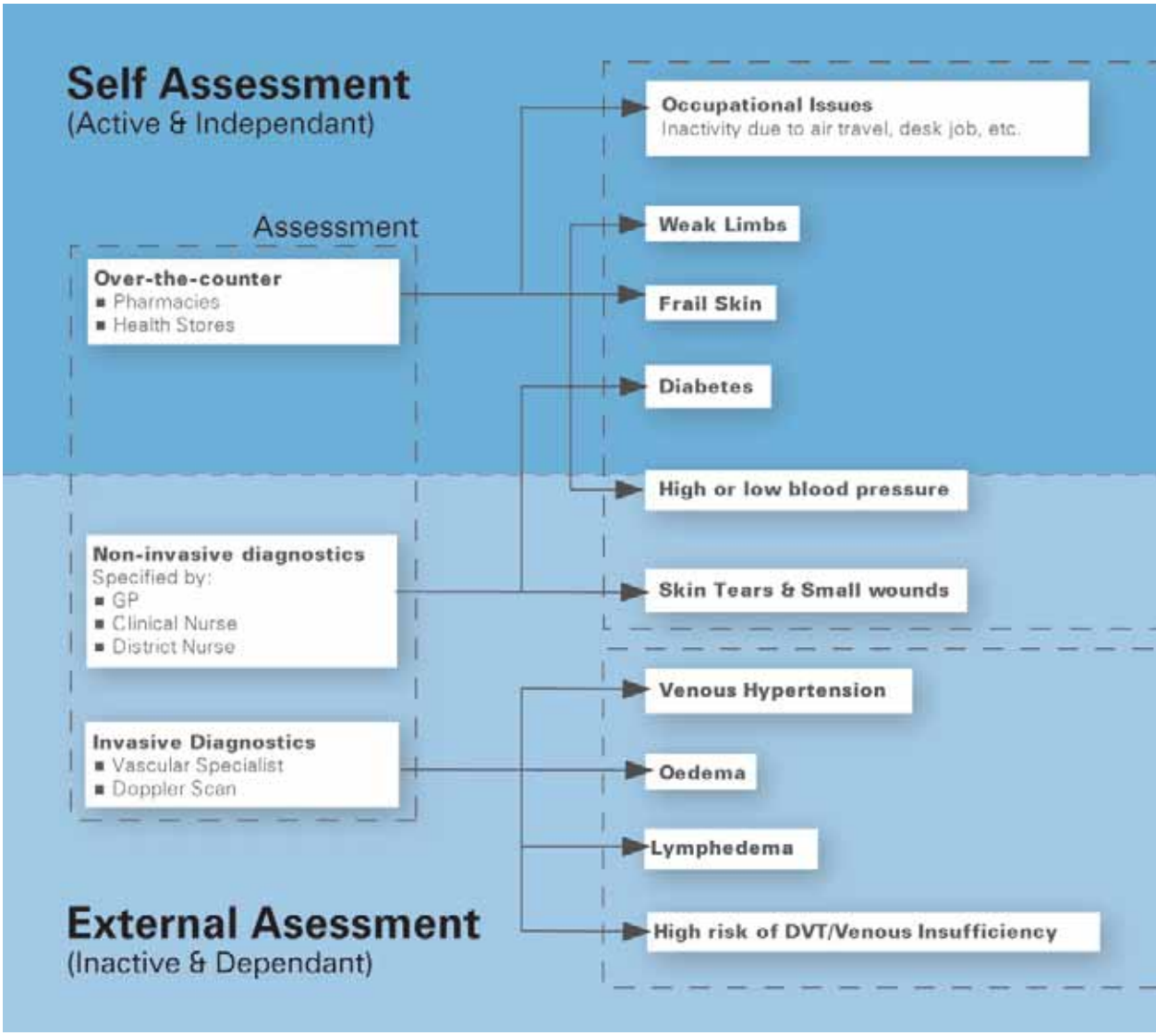
Specifying External Compression

The patient's needs and lifestyle requirements need to be assessed before treatment.
A systematic approach to assessment is recommended that includes:

Minor cases (requiring preventative treatment)

- **Skin condition** – delicate friable skin can be damaged by high levels of pressure
- **Shape of the limb** – the sub-compression pressure and the pressure gradient will be altered by the limb shape in accordance with Laplace's Law. Skin overlying exposed bony prominences may be subject to pressure damage
- **Presence of neuropathy** – the absence of a protective response increases the risk of sub-compression pressure damage

Figure 10. Recommended Pathway for Assessment



- **Consideration of the patient's age, dexterity and any other disabilities** - This will influence the type of compression prescribed.
- **Allergies Assessment** - Possible allergens should be noted.

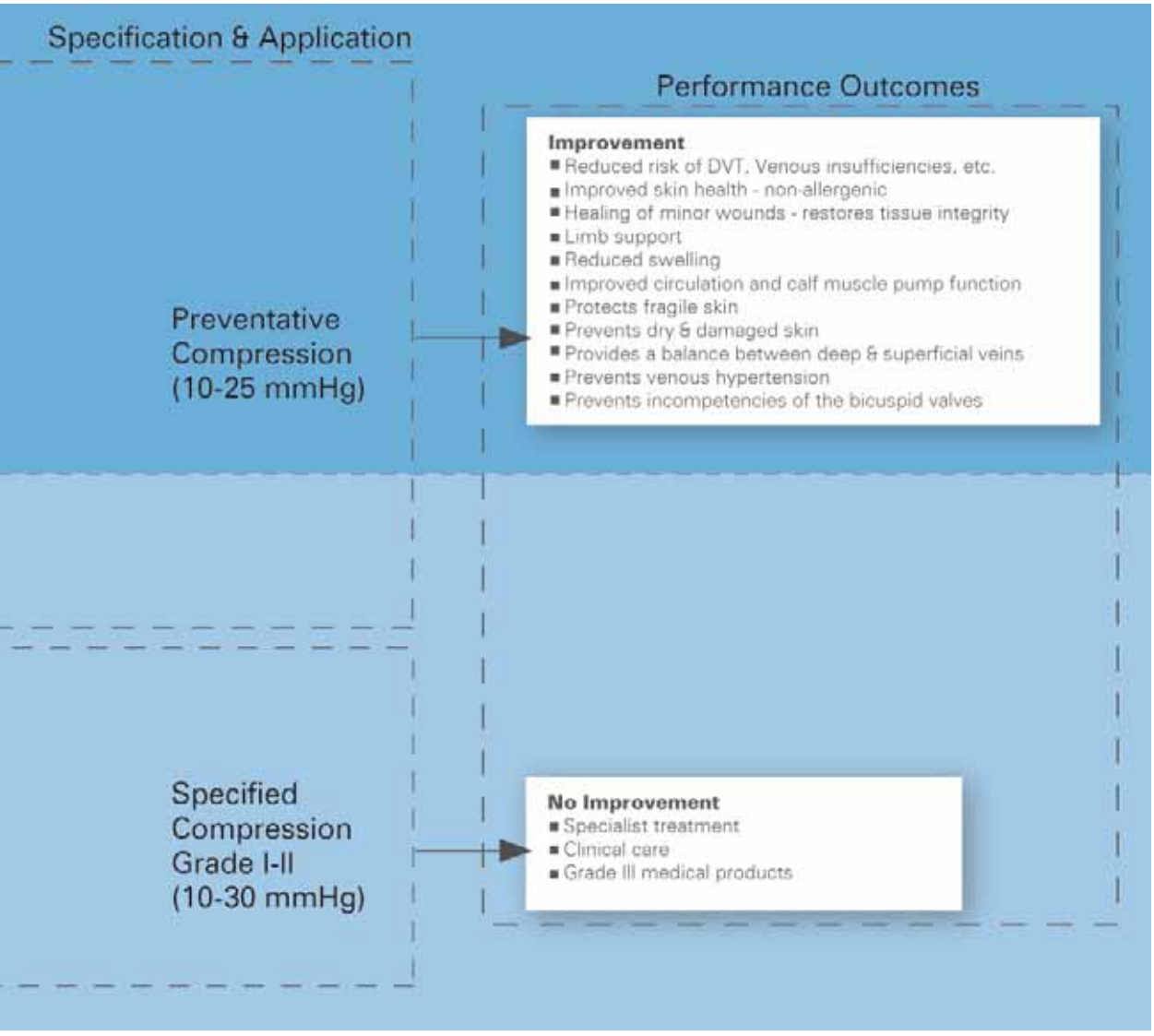
Severe cases (requiring clinical treatment)

- **Evaluation of the peripheral limb circulation.** Doppler ultrasound to estimate the ankle brachial pressure index (ABPI).
- **Presence of cardiac failure** – rapid fluid shifts can be dangerous as it increases the preload of the heart

When Not to Use External Compression

External compression should be avoided for Patients with arterial disease (complications with the main arteries which distribute blood through the body in the direction away from the heart), as it may cause preloading on the heart, necrosis or ulceration, or in severe cases, amputation may be required.

Compression should also be used with caution in those with diabetes mellitus or rheumatoid arthritis, as these patients are susceptible to small vessel disease . Arterial perfusion should be evaluated using a Doppler ultrasound to calculate the ankle-brachial pressure index (ABPI).



Consumer Research

The target customer for the Encircle project is adults 50 years of age and older. Specialists involved in the supply and sales of compression, patient assessment, product specification and application have also been investigated during the course of this research.

The effect of ageing causes several physical changes in the older adult. Loss of height, weight, range of motion and strength are attributed to age-related changes in vertebral compression, loss of muscle tone and mass, muscle fibres and muscle size, and general posture. As a result, anthropometric dimensions of the elderly vary significantly from standard sizing of middle aged adults (refer to the Older Adult Anthropometry table).

Table 4. Older Adult Anthropometry

Measuring Points	Code	Age	Sex	Mean	5th %ile	95th %ile
Ankle Circumference	cB	60-99	M	245.3	218.9	273.8
		60-99	F	239.4	206.5	272.6
Calf Circumference	cC	65-85+	M	415.0	369.9	460.2
		65-85+	F	388.6	344.3	434.3
Top of Calf Circumference	cD	65-85+	M	340.7	291.9	397.9
Top of Thigh	cG	60-99	M	478.0	387.0	553.5
		60-99	F	486.0	388.5	565.5
Bicep Circumference	f	65-85+	M	245.4	189.0	314.0
		65-85+	F	244.8	176.0	317.0
Wrist Circumference	c	60-97	M & F	199.4	169.9	228.9
Height	H	55-85+	M	1691.6	1520.0	1849.0
		55-85+	F	1560.5	1415.0	1695.0
Weight (kg)	W	55-85+	M	76.4	55.2	107.0
		55-85+	F	65.3	43.7	95.0
Foot Length	L	65-85+	M	256.9	233.8	280.8
		65-85+	F	234.6	210.0	257.4
Arm Length (wrist to shoulder)	CH	65-85+	M	619.2	555.5	659.5
		65-85+	F	565.3	507.7	628.9

Figure 11. Older Adult

Older Adult Requirements

A range of discussions and observational studies were undertaken during November in the Bay of Plenty area with nursing staff and elderly care professionals to form a picture of the end user requirements for compression products. Key insights from these discussions are outlined here from the definitive User Requirements.

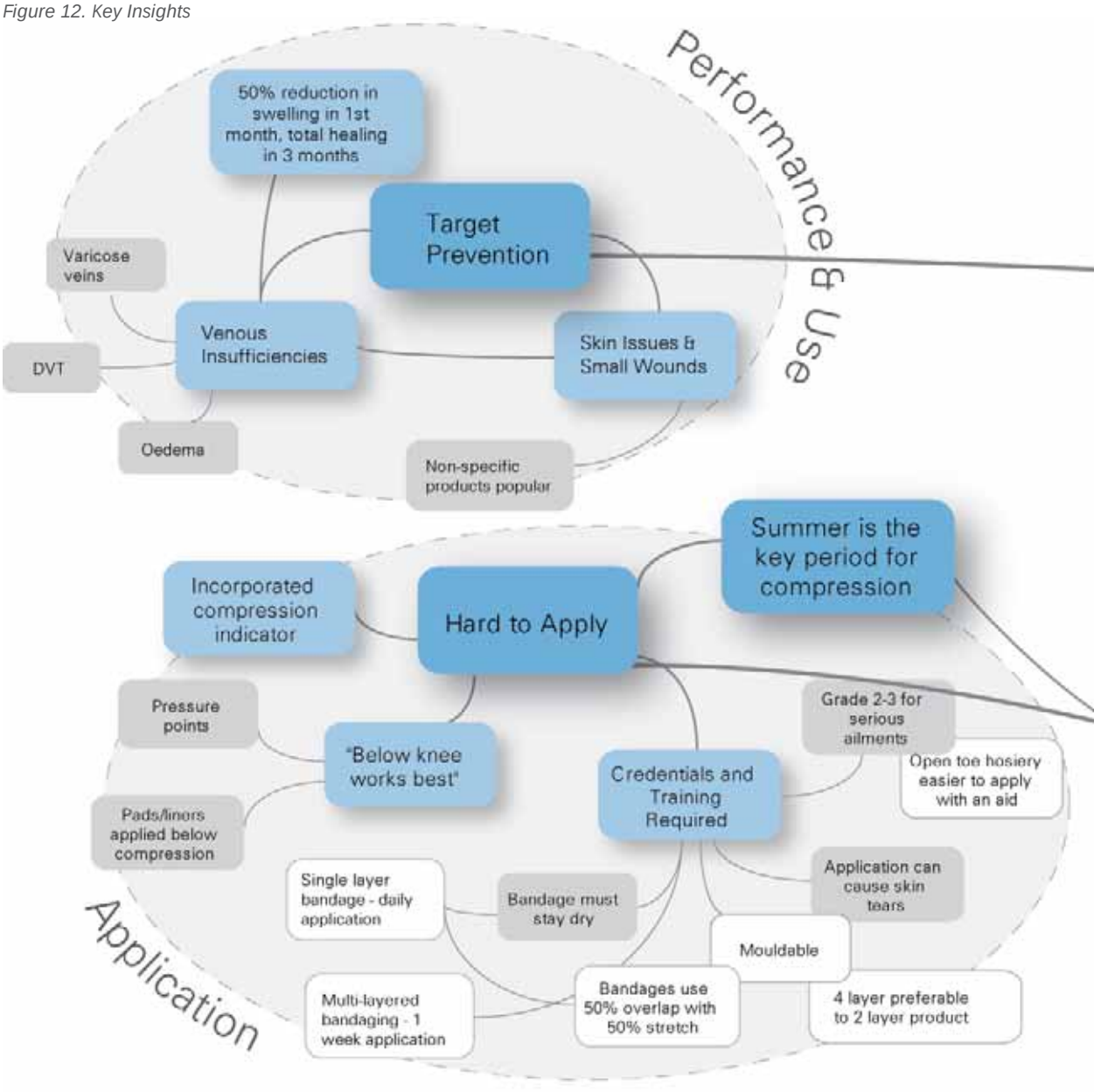
Comfort

One of the biggest issues with specifying the correct item is comfort. Many people indicated that there is a lot of non-compliance in summer due to higher temperatures and existing products that are very hot. Unfortunately, summer is when compression therapy is most critical for the patient due to higher temperatures causing swelling of the limbs.

Ease of Application

Applying compression products has been referred to as a hard procedure by all. As the compressive value (class) gets greater, the items get significantly harder to apply. This issue is magnified for patients with limited physical capability and fragile skin, who represent a large proportion of the elderly community. The aim is

Figure 12. Key Insights



also to not create any pressure points which can lead to the formation of an ulcer.

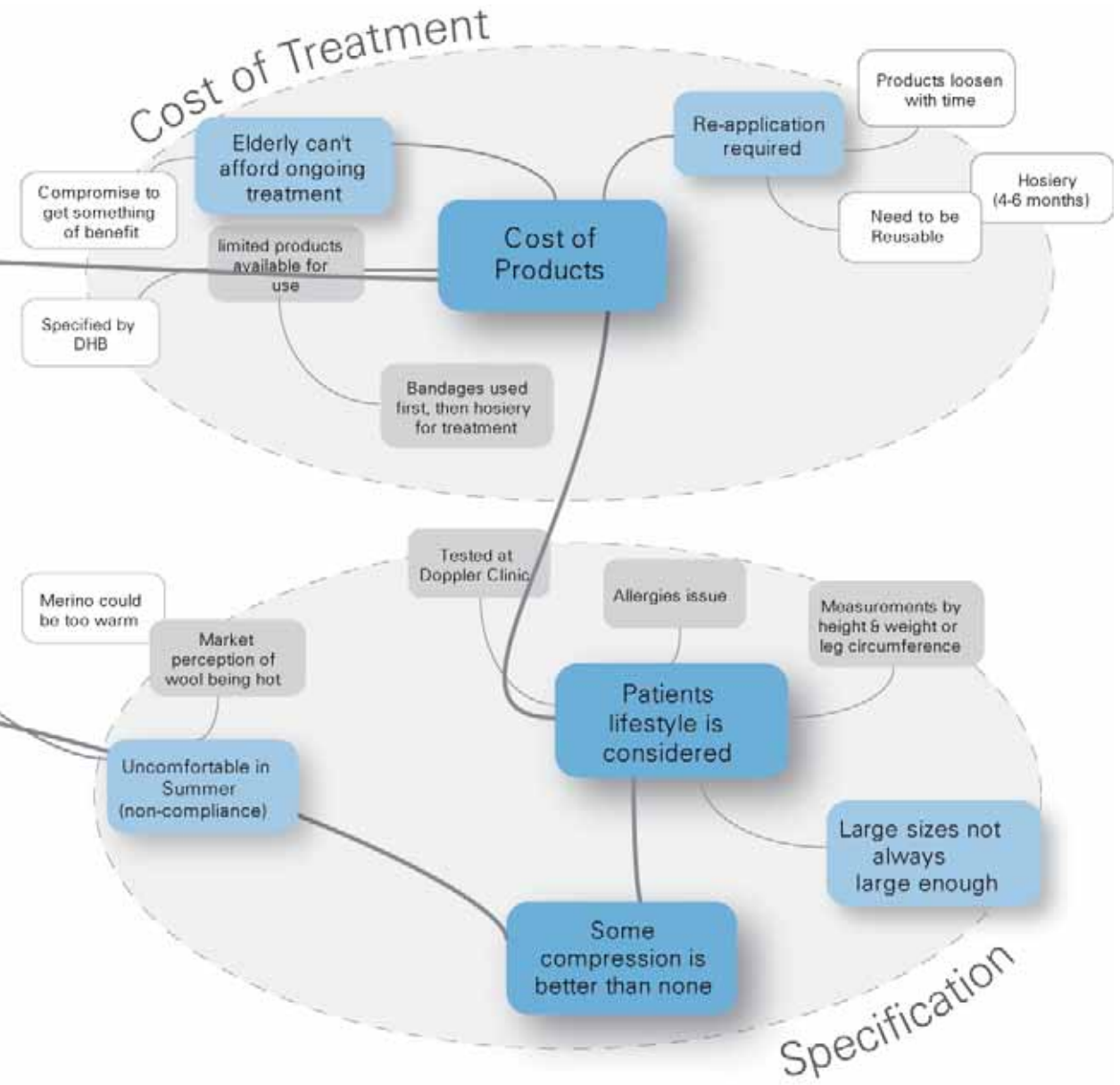
Performance

The general objective for compression application within the sector of the industry approached during this study is to deliver 50% reduction in swelling in the first month, with total healing within 3 months.

Cost

Cost has been identified as a major consideration for both those that specify compression and the end user. Information collected indicates that existing products are too expensive for many patients and it has been suggested that quite often there is a compromise between cost, application, and the patient's needs.

Part of this cost issue may also be linked to the limited products available for application, or because several products require re-application over a prolonged period. This creates an increase in treatment costs for the elderly, of which many, as it has been suggested, cannot afford ongoing treatment.



Product Benchmarking

Assessment of the existing state of the art technologies is an important aspect of any product development project as it helps establish a broad understanding of what products and systems are already available and what level of freedom a manufacturer may have to operate in a particular product category. It also helps to better understand the various strategies of existing companies in the market

Comparative Assessment

A wide range of competing products were assessed in detail to establish the existing benchmark of compression technologies and to identify which companies are setting the standard. Products assessed included bandages, hosiery, orthotics, and wound care, which enabled the project team to investigate a range of different aspects including compression level, type of application, general features, supporting material, and an assortment of fibre and fabric technologies.

The key criteria used for this qualitative and quantitative assessment included:

Specification & Application

- Ease of specification
- Suitable for 'self application'
- Indicates when the correct compression has been applied
- Clear & easy to follow instructions

Performance & Construction

- Materials, construction & burst strength
- Washable & reusable
- Comfortable to wear
- Lightweight & breathable

Value for Money

- Competitive Cost

Table 5. Product Attributes

Item	Ease of Specification	Range of Options	Self Application	Indicates Applied Compression	Easy to Follow Instructions	Washable & Reusable	Comfortable to Wear	Lightweight & Breathable
ADAPTIC Non-Adhering Dressing								
Allevyn Non-Adhesive Dressing			•		•			
Comvita ApiNate			•		•			
Convatec SurePress Bandage	•		•	•	•		•	•
ProGuide - Smith & Nephew				•	•			•
Profore - 4 layer system				•	•			
Venosan Legline collection- Silver Ion		•	•		•	•	•	•
Scholl Flight Socks	•	•	•		•	•	•	•
Gloria/Rx Fit	•	•	•		•	•	•	•
Sigvaris		•	•		•	•	•	•
Venosan Legline collection	•	•	•		•	•	•	•
Zipzoc compression sock							•	
Futuro	•	•	•		•	•	•	
Tubi-Grip	•	•	•					
Paladin Life Sock	•	•		•		•	•	•

Comparative assessment revealed that existing products range in value from NZ$16 for a basic bandage up to NZ$170 for full length hosiery garments. It also revealed a range of specific areas which are of interest to the Encircle project that are to be used as benchmarks from which to base the development of compression products for the elderly.

Figure 13. Existing Benchmark

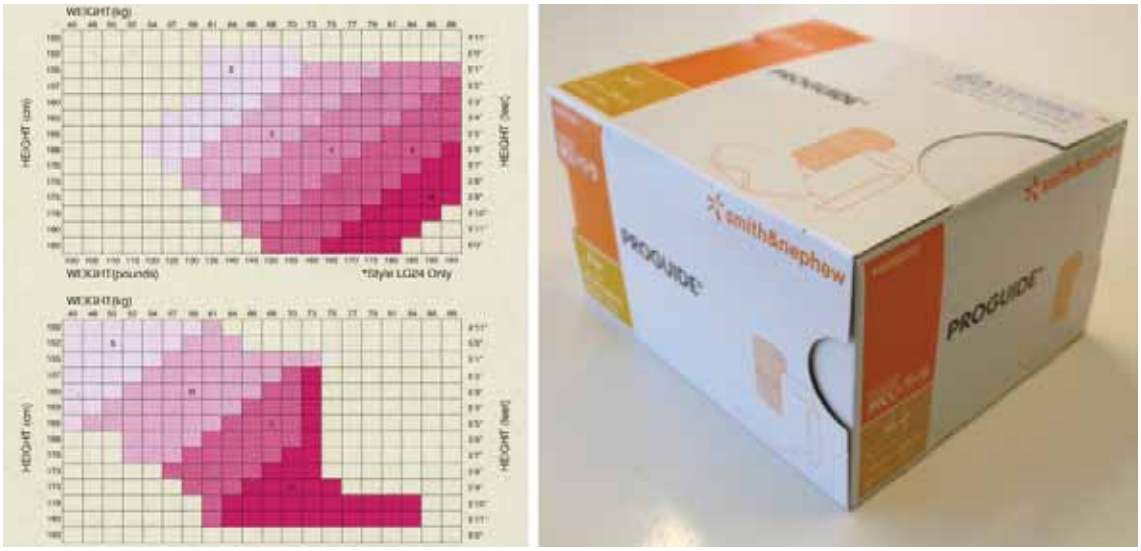


Table 6. Targeted Areas for Development

Product Benchmark	Current State of the Art	Ideal Development
Compression Sizing	RxFit Sizing System	Compression profile and sizing specifications should be clear and easily understood.
		Self specification and measurement by the elderly in store or at home.
		A range of sizes should be provided and should reflect the target demographic.
Pressure Indicator	Convatec SurePress Compression Bandage	Indication of what pressure is being applied is important for self application of the products.
		Responsive and intuitive products to aid application.
		Pressure indicator should be included in the structure of the garment. i.e. knitted or woven into the textile.
Product Presentation	Smith & Nephew Compression Products	Product should be presented in a way that allows easy reading and understanding by the elderly.
		Simple graphics and large, high contrast text.
		Clinical product but accessible as a self applied garment.
Product Application	Paladin Life Sock	All garments should be able to be applied with minimum force to enable the target demographic to apply the garments themselves.
		Garments should only be able to be applied in the correct manner to reduce incidence of injury or further affliction.

Benefits of Merino

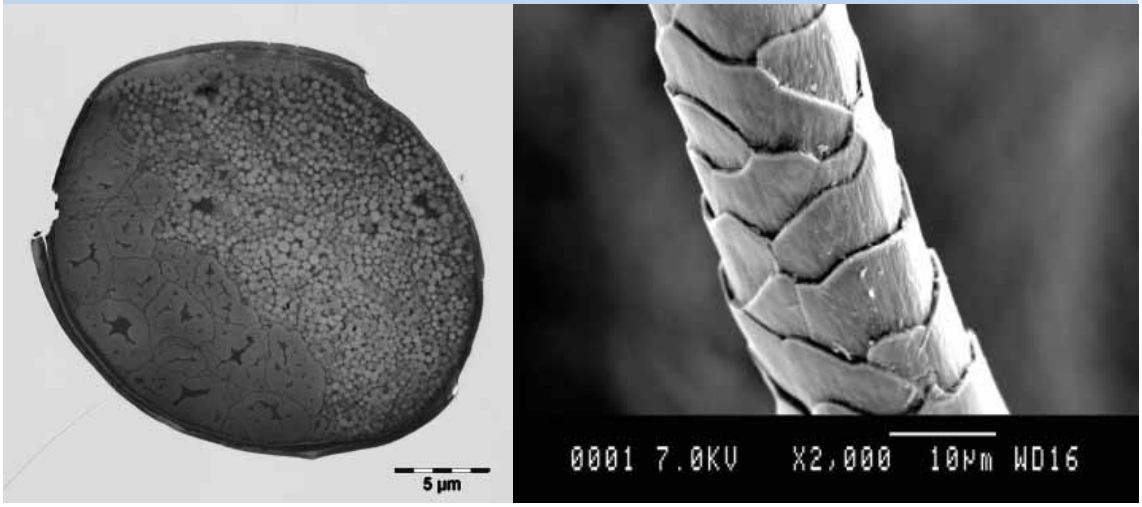
One of the principal concepts behind the Encircle project is to leverage the anti-bacterial and comfort advantages of Merino wool into medical applications, thereby creating a more effective product that can regulate the body for prolonged periods. Preliminary research suggested that the hygroscopic nature of the fibre can assist in creating a regulating barrier or micro-environment for more effective support and management.

A detailed investigation was carried out to ascertain the efficacy of Merino in next to skin therapeutic applications.

Figure 14.Electron Microscope images of the Wool Fibre

TEM (cross-section) of a wool fibre

SEM of a Merino wool fibre



Merino Fibre

Merino fibre is an extremely complex material that is mainly comprised of keratin – a fibrous protein also found in hair, nails and feathers. Keratin is made up of a variety of amino acid building blocks; one which is of particular significance due to its properties is cystine, which includes a 'disulfide bond'. This forms a stabilising 'cross-link' between adjacent polypeptide chains in the protein.

Merino is relatively fine wool (average diameter ~23 μm and lower, although definitions vary) from the Merino breed of sheep.

Merino's Suitability for Compression

The proposed application of merino to compression is largely based on its effectiveness in next-to-skin apparel. Merino wool is able to maintain comfort in a garment system at low levels of activity by absorbing moisture vapour produced by the body which is ideal for the older adult. It can also release perceptible amounts of heat when it absorbs moisture and is very good at absorbing volatile odour-causing compounds so naturally resists odour build-up.

The main drawbacks with Merino in the proposed application include its heat retention and its inability to 'wick' away liquid moisture. In this particular application a relatively high percentage of elastane filaments (e.g. Lycra®) are likely to be necessary to provide good stretch and recovery properties. Similarly, a synthetic fibre may be added to increase strength or modify the moisture interaction of the fabric. Active antimicrobial fibres may be blended in to provide an antimicrobial effect. These blends may be intimate (thorough mixing of fibres), or could take the form of yarn blends (such as bi-layer fabrics).

Figure 15. Standard regain of various textile fibres

Much of wool's comfort advantage is due to the fact that it is a hygroscopic fibre capable of absorbing and desorbing moisture vapour from the external environment or body microclimate (between the body and the clothing layers). Synthetic fibres are not hygroscopic, a fact illustrated in this graph, in which the standard regain of various fibres is charted (this is the amount of water in the fibre expressed as a percentage of its dry weight in standard conditions – 20°C, 65% relative humidity).

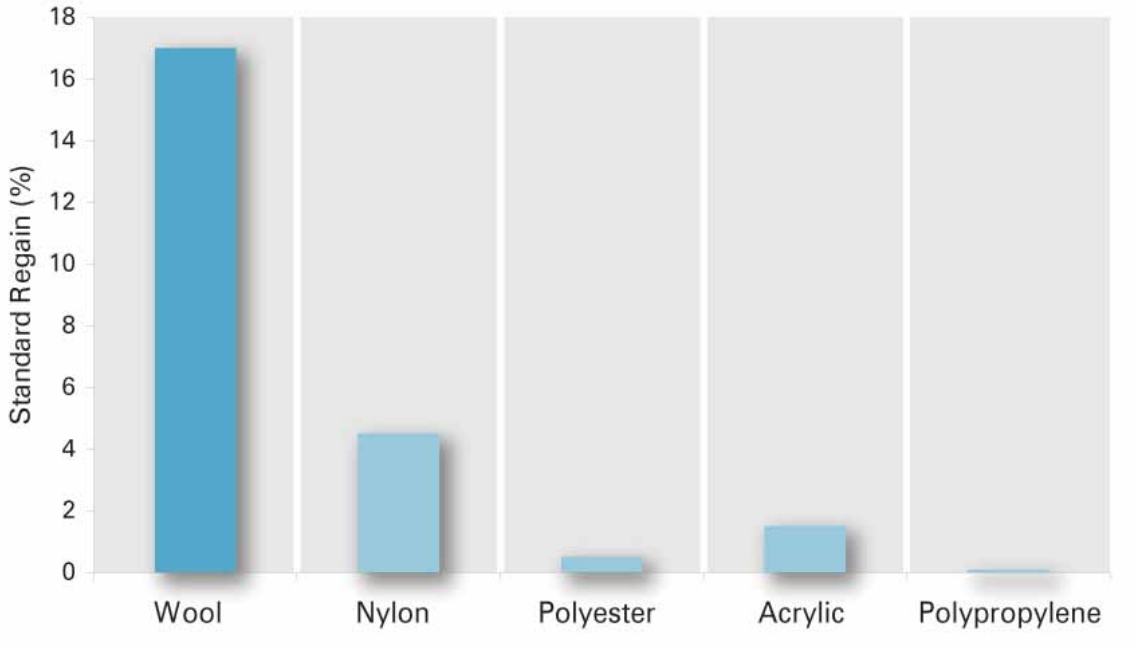


Table 7. Pro's & Con's of Merino in Compression Applications

Strengths	Weaknesses	Possible strategies to address weakness
Absorption of moisture vapour without feeling wet	Inability to 'wick' away liquid moisture	Modify wool to make surface hydrophilic; blend with wicking fibres
Warmth in cool conditions	Too hot to wear in warmer conditions?	Keep structure as thin and lightweight as possible
Resists odour development	Durability (abrasion, strength)	Establish suitable yarn structure; blend wool with strong synthetic fibre
Possible antimicrobial effect	Prickle	Ensure fibre is sufficiently fine – understand sensitivity of skin of target consumer
Natural fibre with good skin compatibility	Presence (real or perceived) of agricultural residues (including lanolin)	Ensure wool is thoroughly cleaned; carry out residue analysis of product
Flame retardant		
Low static generation		

Key Insights & Opportunities

The Foundation Research has identified a range of key insights and opportunities which relate specifically to the development of a new systematic preventative compression system. The following section briefly discusses these aspects and how they should be managed in the context of the Encircle project.

Cost of Treatment

Cost-effectiveness is a major factor in specifying the appropriate compression system and providing the most appropriate type of treatment to improve the quality of life of the patient. Research indicated that there is a common compromise between cost, application, and the patient's needs.

The real issue with cost effectiveness lies with the 'cost of treatment' due to the lack of a preventative approach. Currently only a small section of the public are using products before a

Figure 16. Customer Cards

problem arises, and once they have a problem, the cost of treatment is high due to many products requiring re-application over a prolonged period.

A study of the cost effectiveness of two treatment options for over 100 patients with venous ulcers over a 52 week period in the UK indicated that the average cost to heal an ulcer per patient is in the vicinity of €1,205 to €2,135. This is extremely high and for some elderly this maybe out of their reach.

Considering the cost of the products assessed during the product Benchmarking (NZ$16 for a basic bandage up to NZ$170 for full length hosiery garments) there could be significant cost savings created for the end user and both the public and private health sector if there was a more proactive approach taken towards investing in 'preventive care' rather than the clinical treatment.

Specific Compression for the Older Adult

Assessment of the older adult anthropometric data has concluded that their bodily measurements are smaller than those of the general population, and that reduced mobility in limbs and extremities will make application of the products difficult.

Development of a new range specific to the older adult dimension will aid in minimising the difficulty faced in applying the product. It is also important to note that very few manufacturers are providing specific ranges for the older adult.

Merino & Summer

The resistance from users in wearing external compression, particularly hosiery, during the summer months is concerning. This is the period when compression therapy is most required.

The perception of the general public is that wool is warm and could perhaps be 'too warm'. Many people did however feel that it would be more ideal to enclose someone's leg or toes in summer with a natural product. Structuring the compression range into summer and winter products with a varying percentage of wool (less Merino in summer) is thought to be a positive strategy for addressing this issue.

Table 8. Initial Encircle Compression Profile Parameters

Measuring Points		Compression (mmHg)			Anthropometry Range		
Code	Description	Class A	Class 1	Class 2	5th	Mean	95th
W	Weight	49.5	70.9	101.0			
H	Height	1467.5	1626.1	1772.0			
			Leg Compression				
cB	Ankle Circumference	10>14	15>21	23>32	212.7	242.4	273.2
cC	Calf Circumference	70-100%	70-100%	70-100%	357.1	401.8	447.3
cD	Top of Calf Circumference	50-80%	50-80%	50-80%	340.7	291.9	397.9
cG	Top of Thigh	20-60%	20-60%	20-60%	387.8	482.0	559.5
L	Foot Length				221.9	245.8	269.1
			Arm Compression (Sub-bandage Pressure)				
CH	Arm Length (wrist-shoulder)	531.6	592.3	644.2			
f	Bicep Circumference	14.2 – 25.2	21.3 – 37.9		182.5	245.1	315.5
d	Forearm Circumference				NA	NA	NA
c	Wrist Circumference	19.0 – 25.2	28.3 – 37.9		169.9	199.4	228.9

Recommendations for Development

It has become more apparent through the course of this investigation that the development of a cost effective, systematic preventative compression system that can simplify the process of assessment, specification, and application for the elderly before severe conditions develop and result in medical treatment, is essential.

It is recommended that the next phase of development focuses on the following aspects:

Create a Micro-Environment

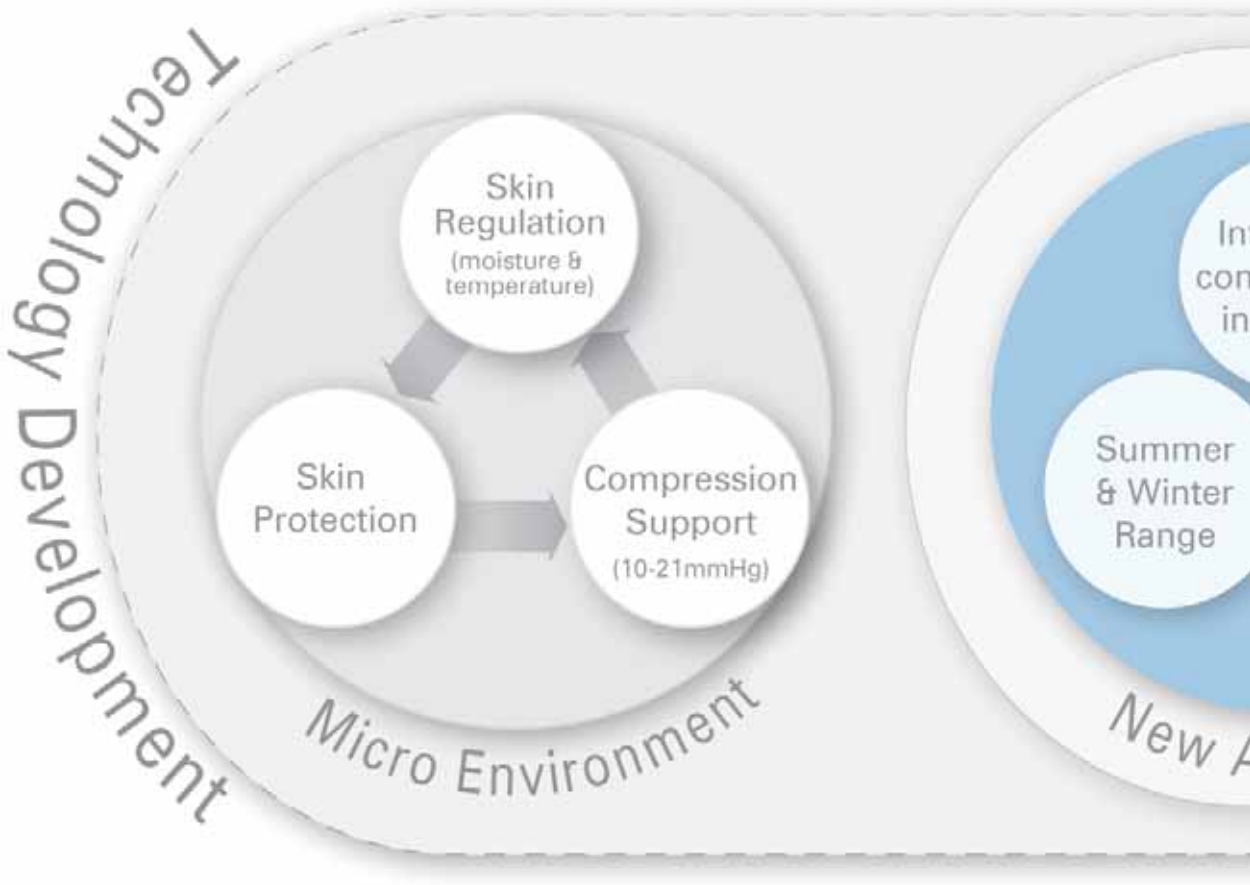
In order to prevent and/or treat skin and venous insufficiencies, effective prevention needs to start by firstly managing the skin and superficial circulatory system.

The goal for Encircle project needs to be the creation of a natural protective barrier or micro-environment that can protect delicate friable skin and regulate skin moisture & body temperature while providing sufficient compressive support.

Technical Fabric Development

The technical fabric development needs to be focused on keeping the material as fine and lightweight as possible and modifying Merino to make the surface hydrophilic. The immediate strategy for this is blending Merino with wicking fibres which would also aid in establishing a suitable yarn and fabric structure for the product.

Figure 17. Proposed Encircle Product System



New Product Application

A new product format or method of application is required for the proposed micro-environment. The new product needs to be applied very easily with limited force to enable the target demographic to apply the garments themselves.

Garments should only be able to be applied in the correct manner to reduce incidence of injury or further affliction. It must not create any pressure points, which can cause irritation or ulceration.

Compression & Positioning Indicator

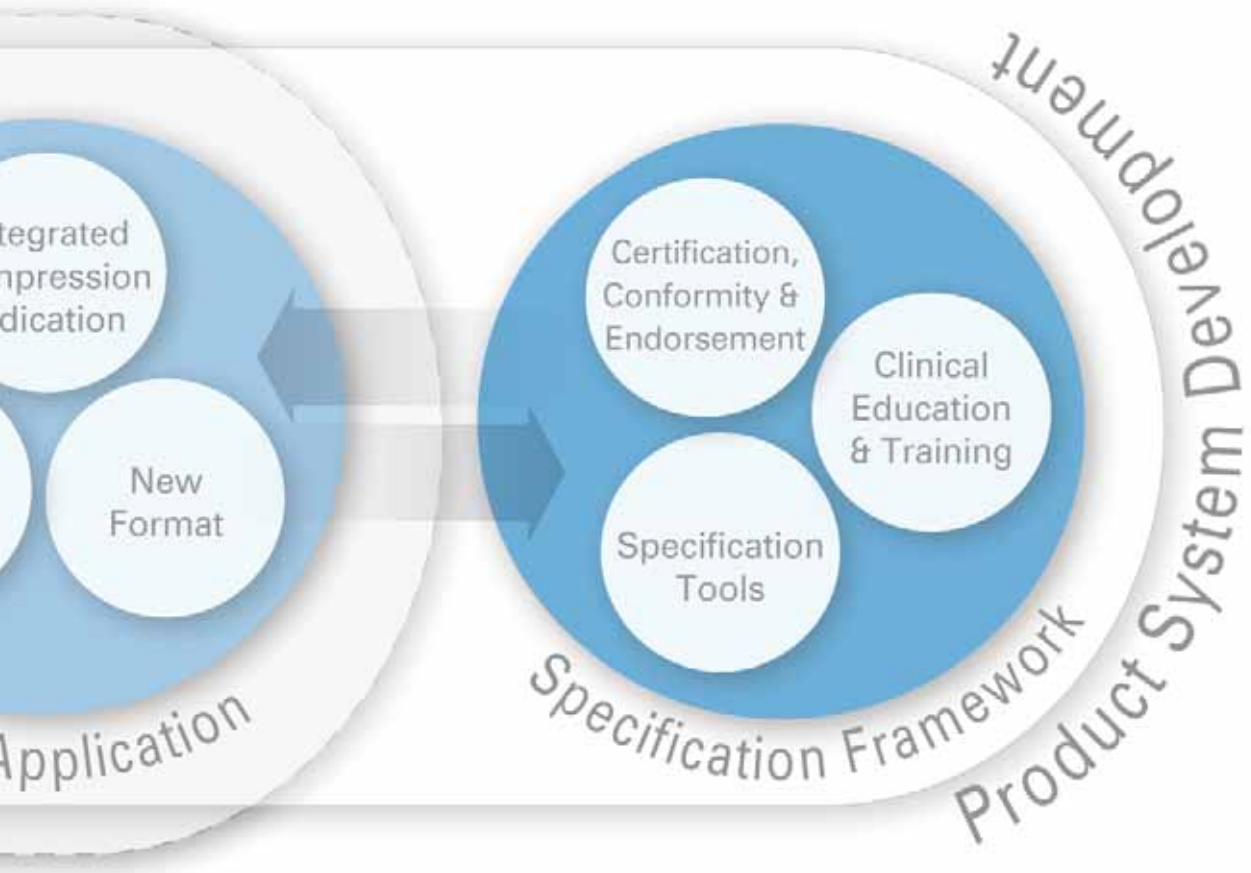
Included in or on the surface of the product needs to be a visual device that indicates to the user when the correct compression has been achieved and when the garment has been applied correctly. This would provide a visual aid to the user helping to enhance their confidence in the product. It would also provide a physical reference for the creation of a more effective specification framework.

This indicator needs be knitted or woven into the fabric or applied to the surface of the garment.

Effective Specification framework

This study has also highlighted a range of other product system requirements and criteria that need to be considered as part of the holistic preventative compression system. The development of more effective specification framework which includes a simple assessment procedure along with easy to use measuring and garment sizing tools would take the guess work out of diagnosis and specification for all those involved.

As mentioned above, this specification framework ideally needs to be physically linked to the product. The development of the compression indicator in or on the surface of the product would provide the visual linkage required to systemize self assessment and correct product specification for the elderly.



Product Presentation

Product should be presented as a system in a way that allows easy reading and understanding by the elderly. Simple graphics and large, high contrast text is essential.

Technical Criteria

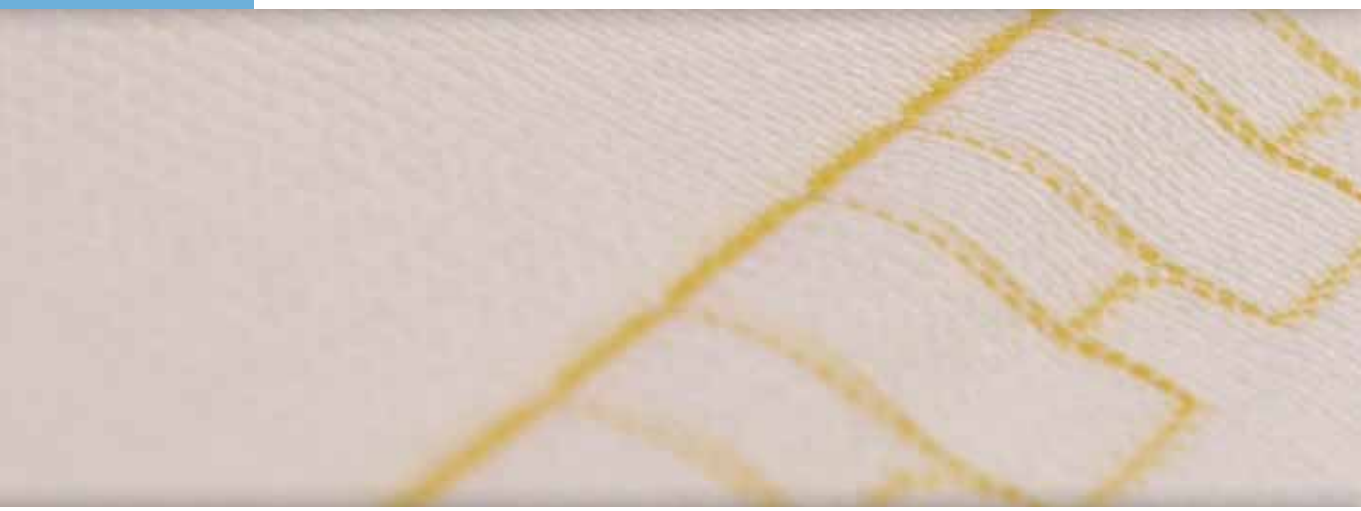
During the course of this investigation a range of other aspects were identified which will form part of the technical development criteria. These aspects relate to the target performance and physiological benefits of the new product and guidelines for patient assessment, correct product specification and application will govern how it is to be used.

Table 9. Key Criteria for Development

Aspect	Criteria
Performance	◢ Sustained compression – ability to provide and maintain effective levels of compression
	◢ Conformable and comfortable (non-slip)
	◢ Clinical effectiveness provided by evidence based preventative treatment
	◢ Heals ulcers within 12-15 weeks should one develop
	◢ Achieved the compression profile in the knitting process, not by shaping the garment after knitting
	◢ Be capable of being stretched by 120% in circumference, and 30% in length at specific points along the leg.
	◢ Be retained for approximately six months of normal use.
Physiological Benefits	◢ Prevent venous hypertension
	◢ Reduce hydrostatic pressure and balance between the deep and superficial veins
	◢ Prevent incompetence of the Bicuspid valves
	◢ Non-allergenic – account needs to be taken of known and likely allergens
	◢ Protect skin and provide effective skin management
	◢ Quickly restores tissue integrity should small wounds be present
Assessment	◢ Effective assessment is essential and needs to be built into the specification and application of the product
	◢ Clear delineation between arterial and venous concerns
Specification	◢ Easy to select and modify the right level of compression
	◢ Integration and understanding of Laplace's Law
Application	◢ Easy to apply correctly before a condition develops
	◢ Indicator for level of compression being applied
	◢ Sufficient support provided for application and training
	◢ Applied with hand strength of less than 200N

The Encircle project was initiated to explore opportunities to create a new healthcare business venture within Levana Textiles. Over a period of four months, research was undertaken to identify the requirements for the development of a new non-invasive, preventative compression system.

This Booklet forms an overview of the research which will form the foundation for the technical development of blended Merino compression products for the elderly. It aims to clearly illustrate the opportunities for Levana Textiles and presents several recommendations for the Encircle project.



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